MaryLie/IMPACT: A Parallel Particle Simulation Code with Space Charge for Modeling Beam Dynamics in Linacs and Rings

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Performed in Collaboration with

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- T. Mottershead, P. Neri, P. Walstrom, LANL
- J. Qiang, LBNL
- R. Samulyak, BNL
- V. Decyk, UCLA

MaryLie/IMPACT: Overview

- **MaryLie/IMPACT (ML/I) is a hybrid code that combines the beam optics capabilities of MaryLie with the parallel PIC capabilties of IMPACT**
  - Inherits MaryLie map generation routines, map analysis routines, optimization capabilities, program flow capability, (enhanced) front end
- **Enhanced front end**
  - MAD lattice description, also backward compatible w/ MaryLie
  - Methodical treatment of units!
- **Wide applicability**
  - Linear, circular, other types of machines
  - With and without space charge
  - With and without acceleration
- **Performance optimization of tracking routines (25% peak)**
- **Example suite includes benchmarks of test cases w/ known solutions**
- **Wake field module (Developed by R. Samuyak, BNL)**

Treatment of Units in ML/I

- **Issue of units has no doubt caused many accelerator physicists hours of frustration and lost productivity**
  - note my grey hair; lack thereof of some colleagues
- **ML/I allows arbitrary specification of ℓ, $\square$, $\square$, where 6-vector is $(x/\ell, p_x/\square, y/\ell, p_y/\square, \square t, p_t/\square(\square))$**
  - Common choices are:
    - ✔ Magnetostatic systems: $\square = p_0$, $\ell = 1$, $\square\ell/c = 1$
    - ✔ Systems with acceleration: $\square = m_0 c$, $\square = \square_{bunch}$, $\ell = c/\square$
- **New UNITS command:**
  - `myunits: units, l=1.0, p=0.8, w=2.856e9`

New Commands (selected)

- `autoslice:` **automatic slicing of thick elements**
  - `SLICES =` *# of slices*`, L =` *distance between slices*`, CONTROL = local/global/none`
- `autoapply:` **automatic application of a commands**
  - `NAME=` *name of menu element or line*
- `autotrack:` **automatic tracking of particles**
  - `TYPE=taylorN/symplecticN`
- `autoconcat:` **automatic concatenation of maps**
- `poisson:` **select/set parameters of Poisson solver**
  - `NX=,NY=,NZ=,ngridpoints=` *fixed/variable,* `boundingbox=`*fixed/variable...*
- `raytrace:` **ray trace command**
  - `NORDER=, NTRACE=, NWRITE=, SEQUENCELENGTH=, PRECISION=, MIN=, MAX=, INFILE=, OUTFILE=, CLOSE=, FLUSH=`
- `units:` **specification of units**
  - `TYPE=, L =` *scale length*`, P =` *scale momentum* `, F =` *scale freq* `, W =` *scale angular freq*`, T =` *scale time*

Prologues in Particle Data Files

- **Headers contain info regarding the data that follow:**
  - Descriptive text
  - Scale length
  - Scale momentum
  - Scale time
- **Code can read the prologue, convert the data (if desired) to those units being used in the current simulation**
  - Frees the user from the headache of unit conversion

Test Suite

- ✔ **Cold uniform beam in a periodic channel {FODO + rf cavities} with/without space charge**
- ✔ **KV beam in a FODO channel using 3D Poisson w/ periodic boundary conditions in z**
- ■ **Stationary spherically symmetric thermal or bi-thermal distribution in a constant focusing channel**
- ■ ***Long* beam in a 3D constant focusing channel with $k_x \neq k_y$, $k_z \ll k_x, k_y$**
  - In collaboration w/ J. Qiang, I. Hofmann, G. Franchetti